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13. ABSTRACT (Maximum 200 words)

Statement of Problem Studied and Results: This is a collaborative project between the University of Oklahoma (OU) and Boston University (BU) studying the possibility of producing an infrared detector which integrates the function of a spectrometer. The successful implementation of these ideas could lead to a smart infrared detector. The system we are studying as a prototype is the two-dimensional electron system (2DES) GaAs-AlGaAs modulation-doped heterostructure system patterned with very narrow gates. This leads to a transition to an one-dimensional electron system (1DES). We expect this system to be particularly sensitive to infrared radiation just at the crossover from a 2DES to a 1DES. Thus this system is a Dimensionally Self-Regulating Material. We have made considerable progress toward these goals. We have made successful theoretical models of the proposed devices and we have produced and tested the first generation devices electrically. Far-infrared tests are now in progress.

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6. AUTHORS OF REPORT: John E. Furneaux (OU), and Bennett B. Goldberg (BU).

7. LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO SPONSORSHIP DURING THIS PERIOD, INCLUDING JOURNAL REFERENCES:

"Determination of Subband Spacing in Inversion Layers on *p*-type InAs", L. Bu, Y. Zhang, B. A. Mason, and R. E. Doezema, *Phys. Rev. B*, **45,** 11336 (1992).

"Subband Spectrum of a Parabolic Well in a Perpendicular Magnetic Field", C. E. Hembree, B. A. Mason, A. Zhang, and J. A. Slinkman, *Phys. Rev. B*, **46,** 7588 (1992).

"Calculated spin effects in wide parabolic quantum wells", C. E. Hembree, B. A Mason, J. T. Kwiatkowski, J. E. Furneaux, and J. A. Slinkman, *Phys. Rev. B*, Rapid Communications, **48,** 9162 (1993).

"Calculations of the spin dependence of transport and optical properties in wide parabolic quantum wells", C. E. Hembree, J. T. Kwiatkowski, B. A Mason, J. E. Furneaux, and J. A. Slinkman, *Phys. Rev. B.*, **50,** 15197 (1994).

"Computer Simulations of Semiconductor Devices Using one and two Dimensional Variational Approaches", Philip Ryan, *Masters Thesis*, (University of Oklahoma, December, 1992).

"Self-Consistent Study of Landau Level Structure in Inversion Layers on *p*-type InSb", Lihe Bu, *Ph. D. Thesis* (University of Oklahoma, June, 1994).

"Calculated Characteristics of Wide Parabolic Quantum Wells", Charles E. Hembree, *Ph. D. Thesis* (University of Oklahoma, June, 1994).

8. PUBLICATIONS ASSOCIATED WITH THIS GRANT AND WITH THE MATCHING GRANT FROM THE STATE OF OKLAHOMA.

- "IV-VI Semiconductor Quantum Well Lasers, Physics and Engineering", Majed Khodr, *Ph. D. Thesis* (University of Oklahoma, June, 1994).

- "Growth and Characterization of Thallium and Gold Doped $Pb_{0.78}Te_{0.22}$ Layers Lattice Matched with BaF_2 Substrates", Patrick J. McCann, Srinath K. Aanegola, and J. E. Furneaux, *Appl. Phys. Lett.*, **65,** 2185 (1994).

- "Optical Properties of Ternary and Quaternary IV-VI Semiconductor Layers on (100) BaF_2 Substrates", Patrick J. McCann, Lin Li, John E. Furneaux, and Robert Wright, *Appl. Phys. Lett.*, **66,** to be published (1995).

- "Electrical Properties of Thallium and Gold Doped $Pb_{0.78}Te_{0.22}$ Layers Lattice Matched with BaF_2 Substrates", Srinath K. Aanegola, Patrick J. McCann, and John E. Furneaux, *Proceedings of SOTAPOCS XX*, ed. by D. Noel Buckley, (, 1995), in press.

- "Effects of Nonparabolicity on Gain and Current Density in Lead Salt Semiconductor Quantum-Well Lasers", M. F. Khodr, B. A. Mason, and P. J. McCann, *Proceedings of the International Quantum Electronics Conference*, 153 (1994).

- "Design Calculations for Lead Salt Semiconductor Quantum-Well Lasers", M. F. Khodr, B. A. Mason, and P. J. McCann, *Appl. Phys. Lett.*, to be published.

9. PRESENTATIONS WITHOUT REFEREED PUBLICATIONS.

"Calculated Shubnikov-de Haas Spectra in Wide Parabolic Quantum Wells," J. T. Kwiatkowski, C. E. Hembree, B. A. Mason, J. E. Furneaux, *Bull. Am. Phys. Soc..* **37,** 642 (1992).

"Parabolic Quantum Wells in Perpendicular Magnetic Fields", C. E. Hembree, B. A. Mason, and J. Slinkman, *Bull. Am. Phys. Soc..* **37,** 642 (1992).

Combined Inter-Subband Cyclotron Resonance in Inversion Layers on *p*-InSb in Perpendicular Magnetic Fields", J. A. Slinkman, Lihe Bu, B. A. Mason, C. E. Hembree, and R. A. Doezema, *Bull. Am. Phys. Soc.,* **38,** 82 (1993).

"Magneto-Transport in Wide Parabolic Quantum Wells," J. T. Kwiatkowski, C. E. Hembree, B. A. Mason, J. E. Furneaux, and J. Slinkman, *Bull. Am. Phys. Soc.,* **38,** 814 (1993).

"Acceptor Luminescence in Parabolic Quantum Wells," B. A. Mason, C. E. Hembree, J. T. Kwiatkowski, J. E. Furneaux, and J. Slinkman, *Bull. Am. Phys. Soc.,* 38, 815 (1993).

"Parabolic Quantum Well Eigensolver, " C. E. Hembree, B. A. Mason, J. T. Kwiatkowski, J. E. Furneaux, and J. Slinkman, *Bull. Am. Phys. Soc.* 38, 815 (1993).

"Combined Intersubband-Cyclotron Resonance in Inversion Layers on *p*-type InAs in High Magnetic Fields", J. Su, Y. Zhang, L. Bu, B. A. Mason, J. A. Slinkman, and R. E. Doezema, *Bull. Am. Phys. Soc.,* **39,** 267 (1994).

"Dimensionally Self Regulating Materials ", J. E. Furneaux, B. B. Goldberg, and E. Aifer, *2nd International Conference on Intelligent Materials, Williamsberg, VA, 1994.*

"Dimensionally Self Regulating Materials ", J. E. Furneaux, B. B. Goldberg, and E. Aifer, *Workshop on Smart Materials, Brandeis University, August, 1994.*

10. SCIENTIFIC PERSONNEL SUPPORTED BY PROJECT:

PERSON	POSITION	DATES	PLACE
John E. Furneaux	Assoc. Professor	6/16-30, 7/1-8/15/93	OU
Bennett B. Goldberg	Asst. Professor	7/1-31/91, 7/1-31/92, 7/1-31/93	BU
Bruce A. Mason	Asst. Professor	7/1-8/15/91	OU
Anna Golitsyna	Post-Doc.	10/1-31/94	OU
Guatum Dev	Post-Doc	3/1-6/30/94	OU
Sergey V. Kravchenko	Post-Doc.	12/16-31/93	OU
Ed Aifer	Graduate Assistant	7/1/93-10/31/94	BU
Dwayne Appling	Graduate Assistant	6/1-7/30/93	OU
Dave Arnhart	Graduate Assistant	6/15-8/15/91	OU
Joshua Eisenthal	Graduate Assistant	7/1/91-6/30/92	BU
Kory Goldhammer	Graduate Assistant	6/1-8/15/92	OU
J. Timothy Kwiatkowski	Graduate Assistant	7/1-31, 10/1-31/94	OU
Whitney E. Mason	Graduate Assistant	7/1-31/94	OU
John Pastalan	Graduate Assistant	9/1/92-12/31/92	BU
Suzanne Romaine	Graduate Assistant	7/1/92-8/31/92	BU
Phil Ryan	Graduate Assistant (MS 12/92)	5/15/91-8/15/91	OU
C. Scott Wilkin	Graduate Assistant	8/1/91-8/30/92	OU

	(MS done Grad. 6/95)		
Ruhong Zhou	Graduate Assistant	10/1-12/31/93	OU
Dan Welty	Work Study, UG	10/1-12/31/93	BU

11. STUDENTS WORKING ON PROJECT SUPPORTED BY SCHOLARSHIP OR MATCHING FUNDS:

Charles E. Hembree	Graduate Assistant OU Centennial Fellow (Ph. D. 6/94)	5/1/91-6/30/94	OU
J. Timothy Kwiatkowski	Graduate Assistant USEd GAANN Fellow	5/1/91-6/30/94	OU
Majed Khodr	Graduate Assistant OCAST State Support (Ph. D. 6/94)	5/1/91-6/30/94	OU

11. INVENTIONS: None.

DIMENSIONALLY SELF-REGULATING MATERIALS

Statement of Problem Studied: This is a collaborative project between the University of Oklahoma (OU) and Boston University (BU) studying the possibility of producing an infrared detector which integrates the function of a spectrometer. The successful implementation of these ideas could lead to a smart infrared detector. The system we are studying as a prototype is the two-dimensional electron system (2DES) GaAs-AlGaAs modulation-doped heterostructure system patterned with very narrow gates. This leads to a transition to an one-dimensional electron system (1DES). We expect this system to be particularly sensitive to infrared radiation just at the crossover from a 2DES to a 1DES. Thus this system is a Dimensionally Self-Regulating Material.

Summary of important results: We have expended considerable effort to building laboratories both at the OU and at BU. These laboratories are now functioning and producing important data. At BU considerable effort was expended to produce very narrow gate arrays which are necessary for the operation of our GaAs based tunable infrared detectors. We have been particularly successful in these efforts producing gates as narrow as 40 nm and 10 μm long. We have tested these devices electrically and they work as field effect transistors (FET's) as they should. We are now in the process of testing their response to far-infrared radiation.

Here at OU we have concentrated on a two pronged attack to the problem of producing a far-infrared detector which is tunable via a control voltage. We have made considerable progress on the theoretical front to refine our ideas and insure our plans design concepts have a high probability of success. These efforts have resulted in a suite of sophisticated computer modeling codes which allow us to effectively test design concepts. These programs have been very successful within the past few months in providing feedback as to the expected operating points for our first generation devices. The results of these calculations have shown that our basic ideas as to the operating characteristics of the proposed tunable detector are sound and have lead us to be very optimistic about the possibility for producing a viable prototype device within the next couple of years. These results and similar results to test the suite of computer programs on particularly challenging and

interesting physical problems have been reported in the papers and presented at the conferences listed above.

On the experimental side we have performed various far-infrared experiments to demonstrate that there is a possibility to use this detection scheme for infrared detectors in the technologically important 9 μm to 12 μm wavelength region. We have shown this result as reported in papers and in presentations indicated above. In fact we have demonstrated that it is possible to have tunable infrared response in precisely this region with devices similar to those we are producing in GaAs if the material is altered to InAs. Note that our InAs test devices could not function as infrared detectors because they are too primitive; they are only capacitors and their gates are not appropriately narrow. We have also modified our Fourier transform infrared (FTIR) spectrometer so that we will be able to test tunable detectors. These modifications included an insert to enable cryogenic operation which is necessary for our devices, and the implementation of special step-scan and modulation enhancements to the system to allow us to operate the devices. We have successfully performed all of these operations and tested them on less complicated systems of interest. These reports are included above.

In conclusion we have made considerable progress toward the production of a prototype tunable far-infrared detector. We are confident that this goal will be realized within the next couple of years.